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MICROSCOPY OF COKE FROM THREE CANADIAN COALS WITH PITCH ADDITIVES

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MICROSCOPY OF COKE FROM THREE CANADIAN COALS WITH PITCH ADDITIVES

by

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ABSTRACT

Three Western Canadian coals of various ranks, coal 1 ($\bar{R}o$ = 1.08), coal 2 ($\bar{R}o$ = 1.24) and coal 3 ($\bar{R}o$ = 1.42) were carbonized individually and also co-carbonized with 7% of each of three pitches designated as A, B and D, in a 460 mm movable-wall coke oven. Reflectance ($\bar{R}o$) was measured and optical textures were examined and categorized on polished pellets of the resultant cokes. The optical texture of coke from coal 1 was virtually unaltered on co-carbonization, whereas, coke from coals 2 and 3 showed some textural modification. Pitch-coke was recognized in the carbonization products of all three coal/pitch blends of coal 1, but was not observed in the coke from coal 2 or coal 3 blends. A correlation appears to exist between the extent of formation of elongated-flow type anisotropy and the strength of the resultant coke for coal 2 and coal 3 blends. Pitch A appears to contribute to high reflectance values in the coke blends followed by pitch D.

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MICROSCOPIE DU COKE PROVENANT DE TROIS TYPES DU CHARBON CANADIEN ADDITIONNÉ DE BRAIS

par

N.J. Ramey**, J.F. Gransden* et J.T. Price*

RÉSUMÉ

Trois types de charbon de l'ouest canadien, charbon no. 1 ($\bar{R}o$ = 1,08), charbon no. 2 ($\bar{R}o$ = 1,24) et charbon no. 3 ($\bar{R}o$ = 1,42) ont été carbonisés, seuls et additionnés de 7% de trois types de brais désignés par les lettres A, B et D, dans un four à coke à paroi mobile de 457 mm. La Réflectivité ($\bar{R}o$) decomprimés polis obtenus à partir des cokes ainsi formés à été mesurée et leur texture optique à été examinée et catégorisée. La texture optique du coke provenant du charbon no. 1 était pratiquement inaltérée après carbonisation avec additif, alors que celle du coke provenant des charbons nos. 2 et 3 présentait certain modifications. Le coke avec brai était reconnaissable parmi les produits de carbonisation des trois mélanges de charbon No. 1/brai, mais n'était pas visible dans le coke des mélanges du charbons nos. 2 et 3. Une corrélation semble exister entre l'étendue d'une anisotropie de type à écoulement allongé et la résistance du coke provenant des mélanges de charbon nos. 2 et 3. Le brai A semble donner les valeurs de réflectivité les plus élevées aux mélanges, suivi par le brai D.

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INTRODUCTION

Economically it is desirable to produce metallurgical coke of high quality utilizing poor coking or low-rank coals because of the increasing shortage of good coking coals.

Studies by others have shown that the carbonization properties of coals can be altered by co-carbonization with some additives.

This study was conducted to examine the optical texture of coke from the co-carbonization of three coals of varying rank with three pitches and consequently, to assess the effect, if any, these pitches might have on upgrading the rank of the parent coal.

EXPERIMENTAL

MATERIALS

The three Western Canadian coals designated coal 1, 2 and 3, had respective ranks of 1.08, 1.24 and 1.42.

Co-carbonization additives were three pitches designated A, B and D. Pitch A is a coal-derived pitch, B is an oil-derived pitch and D is a coal/pitch-derived pitch.

CARBONIZATION AND MICROSCOPY

Individual coals and coal-pitch blends were thoroughly mixed in a blender, then carbonized in a 460 mm movable-wall coke oven to a final known coking temperature.

The resultant coke from each charge was sampled, mounted in resin and polished to a scratch-free surface. Using a Zeiss OIK reflectance microscope, individual coke samples were examined and 1000 point-counts were taken of the different types of optical textures present (Table 1).

Reflectance ($\bar{R}o$) of optical textures was measured at 546 nm in oil (n oil = 1.516 at 24°C), taking 100 readings on each sample at random over the whole of the sample, with the average representing the reflectance of the particular coke. These are listed in Table 2.

Table 1 - Classification of optical texture in coke

Isotropic	(reactive
Very fine mosiac	(<0.5μ)
Fine mosiac	(>0.5μ <1.5μ)
Medium mosiac	(>1.5μ <5.0μ)
Coarse mosiac	(>5.0μ <10.0μ)
Elongated flow	(fine)
Elongated flow	(medium)
Elongated flow	(coarse)
Domain	(creased)
Domain	(ribbon)
Domain	(undulating)
Domain	(flat-flow)
Basic anisotropy	
INERTS	
Fusinite	
Semi-fusinite	

Table 2 - Coke reflectance and stability of resultant coke from coal-coal/pitch blends

Coal-coal/pitch blend	$\bar{R}o$ coke	Stability
100% Coal 1	8.82	29.3
93% Coal 1 + 7% A	8.48	43.9
93% Coal 1 + 7% B	8.25	49.2
93% Coal 1 + 7% D	8.25	42.2
100% Coal 2	9.52	35.5
93% Coal 2 + 7% A	10.90	54.7
93% Coal 2 + 7% B	9.57	47.7
93% Coal 2 + 7% D	10.20	48.5
100% Coal 3	10.43	29.9
93% Coal 3 + 7% A	11.63	54.4
93% Coal 3 + 7% B	10.89	55.4
93% Coal 3 + 7% D	10.31	55.6

RESULTS

The classification system used to categorize the optical textures of coke shown in Table 1 includes isotropic material through mosaic anisotropy to domain anisotropy.

Figures 1, 2 and 3 are graphs representing the percentage of anisotropic components for the parent coke and for each of the co-carbonization products.

Figure 1, representing coal 1, shows that the parent coke contains a high percentage of fine mosaic anisotropy. However, the coke produced from co-carbonization with pitches A, B and D, shows virtually no change in the optical texture.

Figure 2, representing coal 2, shows that the parent coke consists of a good percentage of fine mosaic anisotropy, a fair amount of medium mosaic and a small amount of elongated-flow anisotropy. Coke produced from the addition of pitch B, shows a marked increase in medium mosaic anisotropy, an increase in elongated-flow anisotropy and a reduction in fine mosaic anisotropy. This direction of alteration in optical texture is increased with the addition of pitch D, followed by pitch A.

Figure 3, representing coal 3, shows that the optical texture of the parent coke consists mainly of domain anisotropy, with smaller percentages of elongated-flow, medium and fine mosaics, in that order. However, with the addition of pitch A, the resultant coke shows an increase in elongated-flow anisotropy, apparently at the expense of the domain anisotropy. The same holds true when pitch D is added, and to a lesser extent with the addition of pitch B.

DISCUSSION

The results of this study demonstrate that coals can be upgraded in optical texture and that the strength of the resultant cokes can be increased by co-carbonization with pitches. Figure 4 shows that the rank of coals can be determined by measuring coke reflectance at a known final temperature. However, data used for this graph were derived from reflectance readings taken on coke from coal carbonized in a laboratory tube furnace to a final coking temperature of 1000°C, whereas, the reflectance readings reported in

Table 2, were measured on oven coke. The dependance of reflectance on temperature is demonstrated here, since coals 1, 2 and 3 appear to be outliers as represented by Fig. 4.

Textural analysis of the cokes from the parent coals and coal/pitch blends, show that a correlation appears to exist between the extent of formation of elongated flow anisotropy and the strength of the resultant coke although this does not necessarily follow with the co-carbonization products from coal 1 (Fig. 1,2,3).

Pitch coke was observed in coke from all three coal/pitch blends of coal 1, amounting to perhaps 1-3% in each case. However, it was not distinguishable in the co-carbonization products of either coal 2 or coal 3.

Table 3 displays inerts and coke textures for individual coals and coal/pitch blends. Coal 2 and coal 3 in particular, show distinct decreases in inert content as pitches are added, whereas, the inert content of coal 1 remains unchanged when pitch B is added and apparently increases in magnitude when pitch A and pitch D are added. Perhaps there is some interaction between the pitches and inerts in co-carbonization, although there is no further evidence of this happening.

Reflectances of pitches and pitch/cokes are illustrated in Table 4, and no direct correlation between pitch reflectance and pitch-coke reflectance is evident. Figure 5 displays the distribution of anisotropic components for the three pitch/cokes. A comparison of Fig. 5 with Fig. 1,2 and 3, shows that the anisotropic components of the pitch/coke are not additive with those of the coal-coke in terms of the resultant anisotropic components of the coal/pitch blends. This would indicate that there is some interaction between the coal and additive on co-carbonization.

Table 3 - Pitch - pitch/coke reflectances

Pitch	$\bar{R}o$ (Pitch)	$\bar{R}o$ (pitch/coke)
A	0.82	12.61
B	0.15	11.47
D	1.24	9.79

Table 4 - Textural analysis of coke and coke/pitch blends

Texture	100% Coal 1	Coal 1 + 7% A	Coal 1 + 7% B	Coal 1 + 7% D	100% Coal 2	Coal 2 + 7% B	Coal 2 + 7% D	Coal 2 + 7% A	100% Coal 3	Coal 3 + 7% B	Coal 3 + 7% A	Coal 3 + 7% D
ISOTROPIC					1.6	0.8	0.1	1.0				
Very fine mosaic	2.5	1.1	1.2	1.7	1.0	0.2	1.5	0.4				
Fine mosaic	49.2	46.0	46.6	44.9	30.9	21.3	21.6	16.9	8.5	7.2	2.8	2.9
Medium mosaic	7.9	8.3	8.9	7.1	18.9	32.9	26.9	29.6	10.9	16.5	17.0	26.4
Coarse mosaic	0.1				0.7	0.4	1.6	3.0	1.3	1.0	6.0	3.8
Elongated flow (fine)	0.9	1.8	0.5	0.6	0.1	0.3	0.5	0.4	0.5	0.4		0.1
Elongated flow (med.)	0.9	1.8	1.8	1.7	1.5	4.9	7.1	9.2	6.7	13.1	18.1	18.5
Elongated flow (coarse)						0.1	0.7	1.6	0.9	1.3	5.2	1.6
Domain (creased)	0.3	0.2	0.1	0.3								
Domain (ribbon)	0.1		0.1				0.3	0.9	4.9	1.8	3.0	0.8
Domain (undulating)					2.3	0.3	1.0	1.1				
Domain (flat-flow)	0.6	0.4	2.3	0.5	0.5	1.1	1.2	0.6	19.8	17.0	7.7	9.1
Total reactives	62.5	59.6	61.5	56.8	57.5	62.3	62.5	64.7	53.5	58.3	59.8	63.2
Inerts	37.5	40.4	38.5	43.2	42.5	37.7	37.5	35.3	46.5	41.7	40.2	36.8
Corrected for inerts (inerts removed)												
ISOTROPIC					2.8	1.3	0.2	1.5				
Very fine mosaic	4.0	1.8	2.0	3.0	1.7	0.3	2.4	0.6				
Fine mosaic	78.7	77.2	75.8	79.0	54.0	34.0	34.5	26.1	15.9	12.3	4.7	4.6
Medium mosaic	12.6	13.9	14.5	12.5	33.0	52.8	43.0	45.7	20.4	28.3	28.4	41.8
Coarse mosaic	0.2				1.2	0.7	2.6	4.6	2.4	1.7	10.0	6.0
Elongated flow (fine)	1.4	3.0	0.8	1.1	0.2	0.5	0.81	0.6	0.9	0.7		0.2
Elongated flow (med.)	1.4	3.0	2.9	3.0	2.6	8.0	11.4	14.2	12.5	22.5	30.3	29.3
Elongated flow (coarse)						0.2	1.1	2.5	1.7	2.2	8.7	2.5
Domain (creased)	0.5	0.3	0.2	.5								
Domain (ribbon)	0.2		0.2				0.5	1.4	9.2	3.1	5.0	1.3
Domain (undulating)					3.5	0.5	1.6	1.7				
Domain (flat-flow)	1.0	0.7	3.7	0.9	0.9	1.6	1.9	0.9	37.0	29.2	12.9	14.4

Table 5 contains measured reflectance readings, and reflectance readings which have been calculated based on pitch/coke and coke yields, assuming that no interaction between coal and pitch had taken place in co-carbonization. The measured reflectance values of the coke from 100% coal show little deviation from the corresponding calculated values based on coke and coke/pitch yields. However, when comparing the co-carbonization products of coal 2/pitch A, coal 2/pitch D or coal 3/pitch A, it would appear that some interaction or alteration between pitch and coal has occurred, because of the higher measured reflectance values.

Table 5 - Comparison of measured and calculated reflectance values

Coal - coal/pitch blend	$\bar{R}o$ (coke) measured	$\bar{R}o$ (coke) + $\bar{R}o$ (pitch) calculated
100% Coal 1	8.82	-
93% Coal 1 + 7% A	8.48	9.01
93% Coal 1 + 7% B	8.25	8.88
93% Coal 1 + 7% D	8.25	8.86
100% Coal 2	9.52	-
93% Coal 2 + 7% A	10.90	9.66
93% Coal 2 + 7% B	9.57	9.56
93% Coal 2 + 7% D	10.20	9.52
100% Coal 3	10.43	-
93% Coal 3 + 7% A	11.63	10.53
93% Coal 3 + 7% B	10.89	10.44
93% Coal 3 + 7% D	10.31	10.39

CONCLUSION

This study shows that in the co-carbonization of coals 1, 2 and 3 with pitches A, B and D, a modification of the optical texture of the resultant coke and an increase in coke strength occur. For coal 3, the coke strength on co-carbonization is improved regardless of the pitch added. For coal 2, pitch A improved coke strength the most, followed by pitch D, and then B. The coke strength of coal 1 altered only slightly on co-carbonization, and since pitch/coke was identified in all three co-carbonization products of coal 1, this suggests that the three pitches in coal 1 acted as binders, rather than modifiers, but conversely, as modifiers for coals 2 and 3.

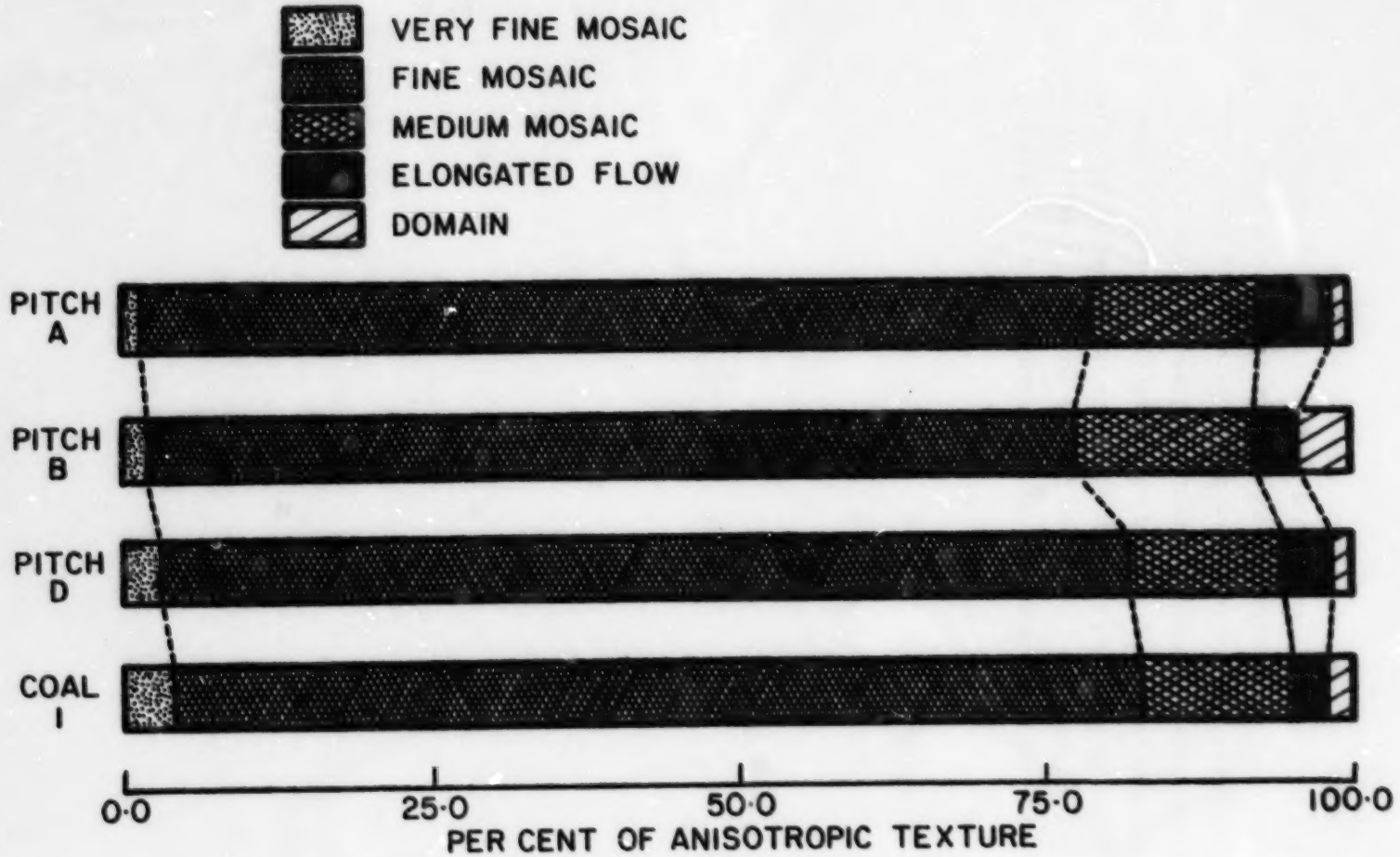

Fig. 1 - Effect of pitch addition on anisotropy type - coal 1

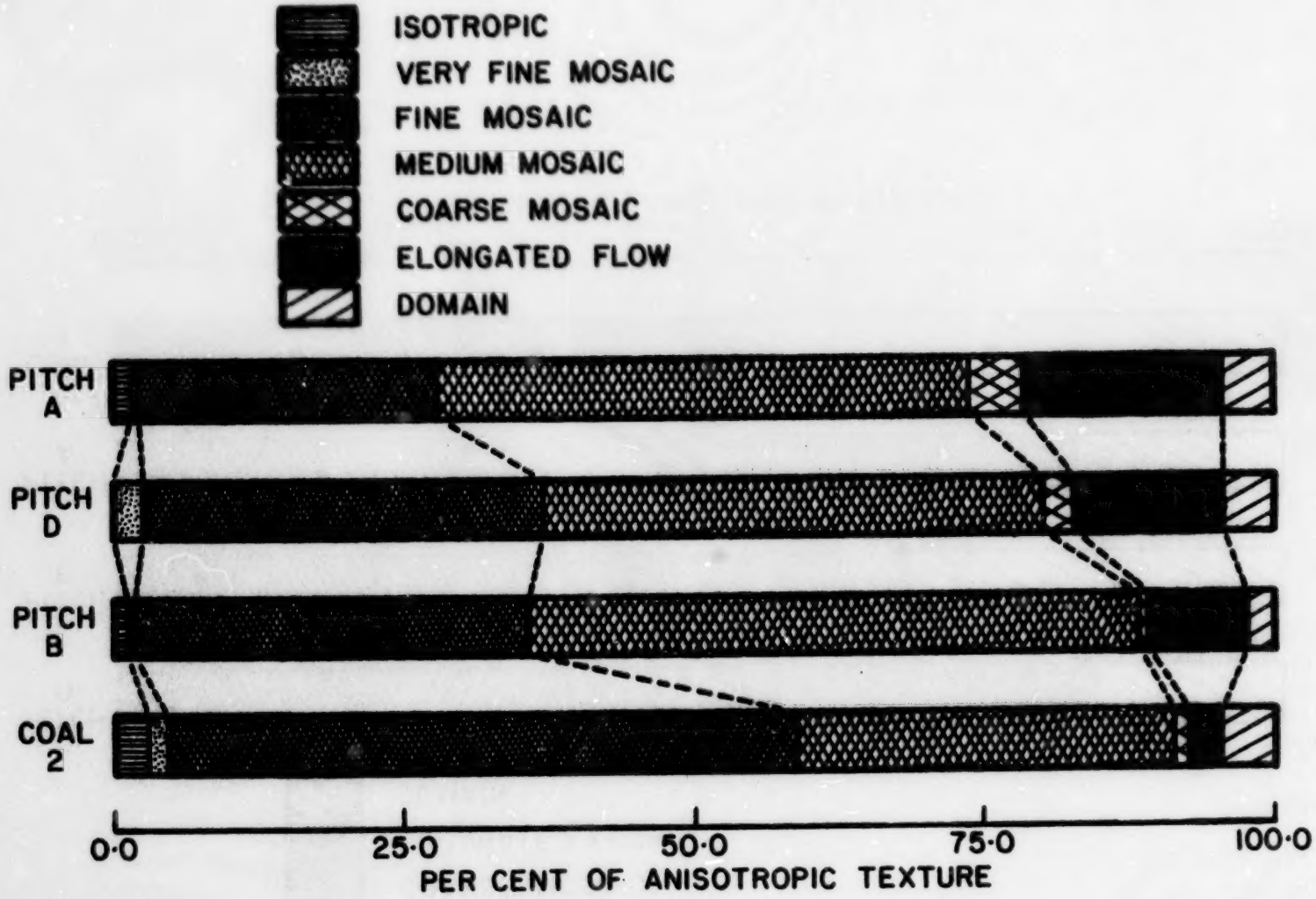

Fig. 2 - Effect of pitch addition on anisotropy type - coal 2

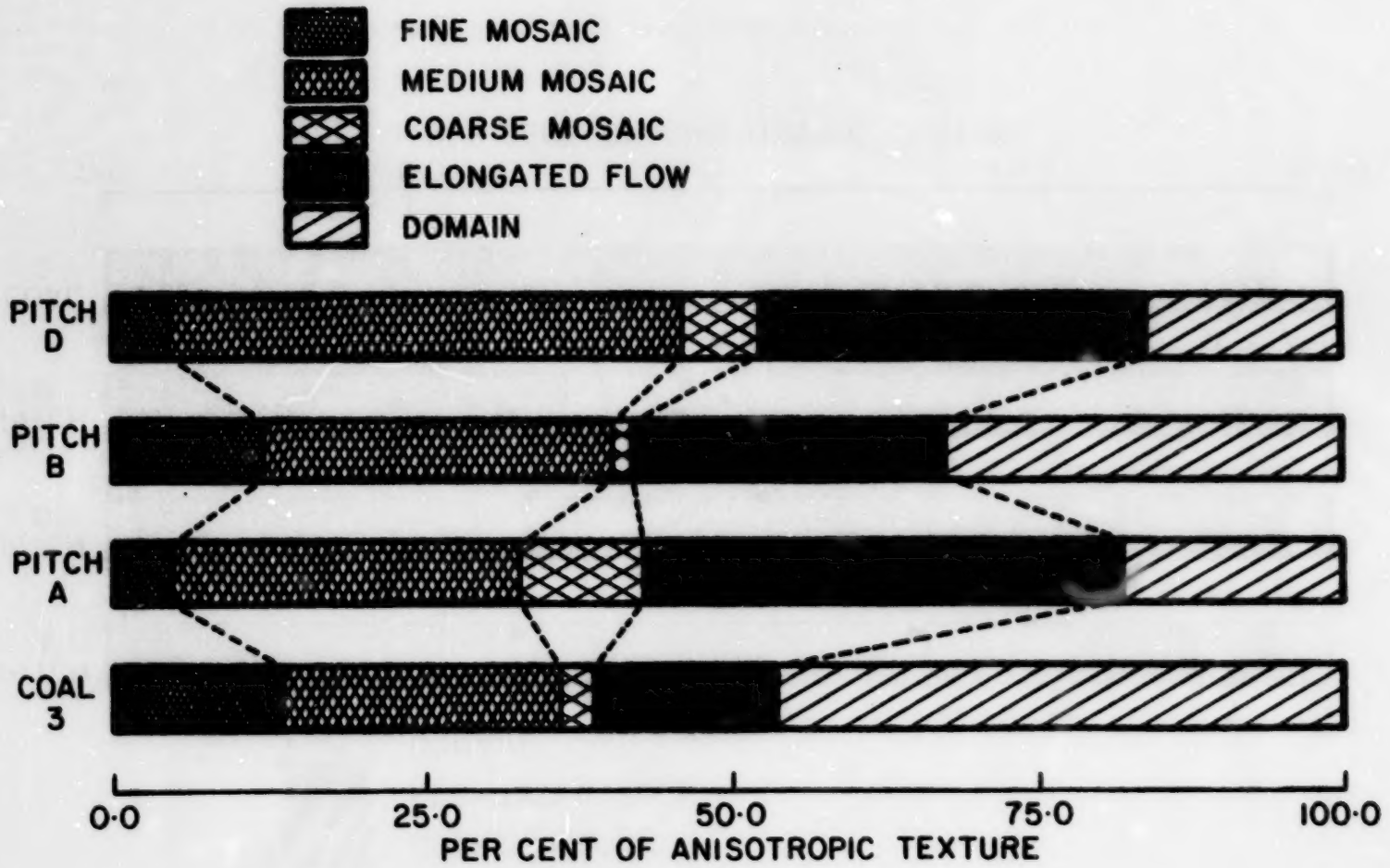

Fig. 3 - Effect of pitch addition on anisotropy type - coal 3

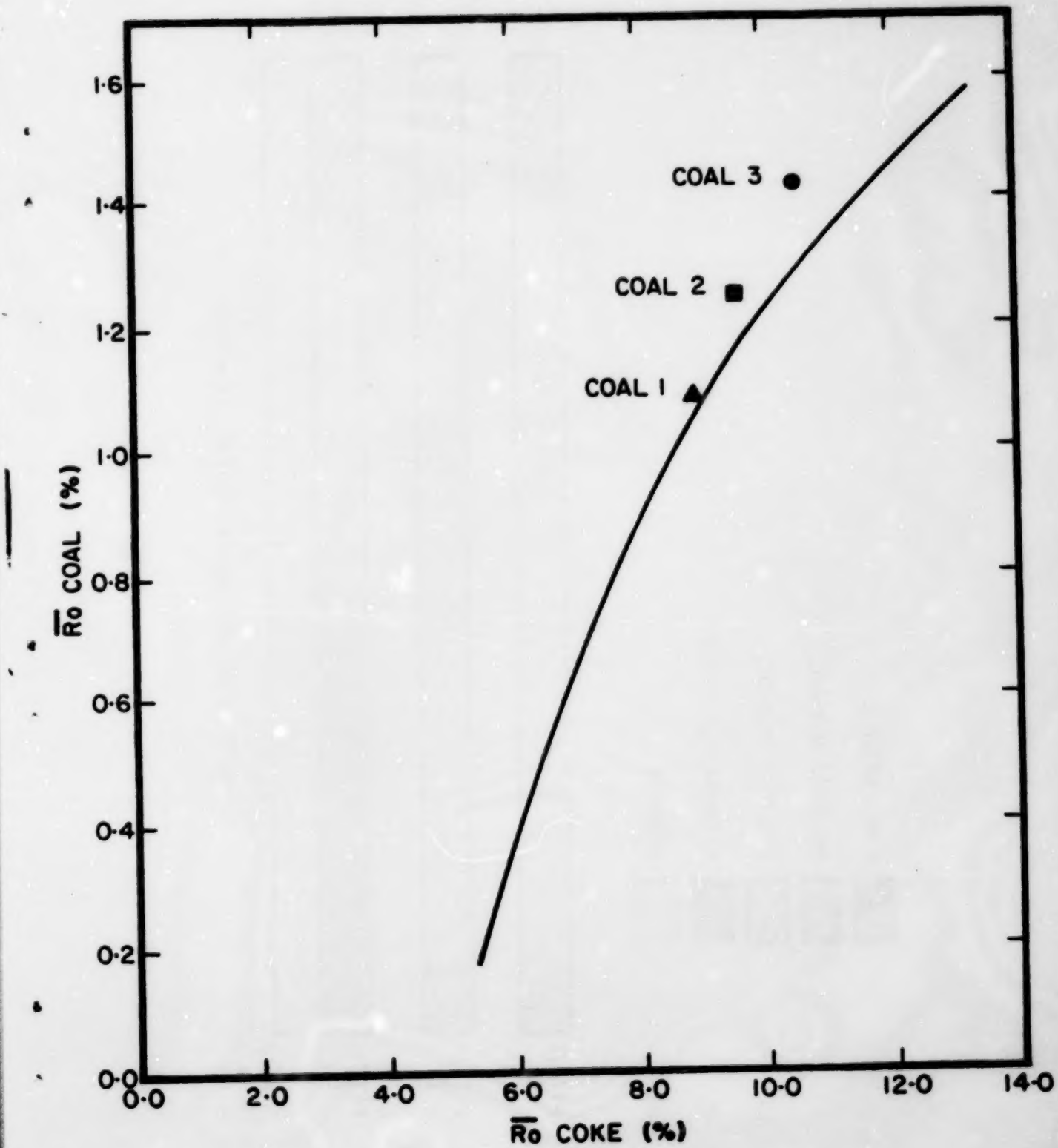

Fig. 4 - Coke reflectance as a means of determining coal rank

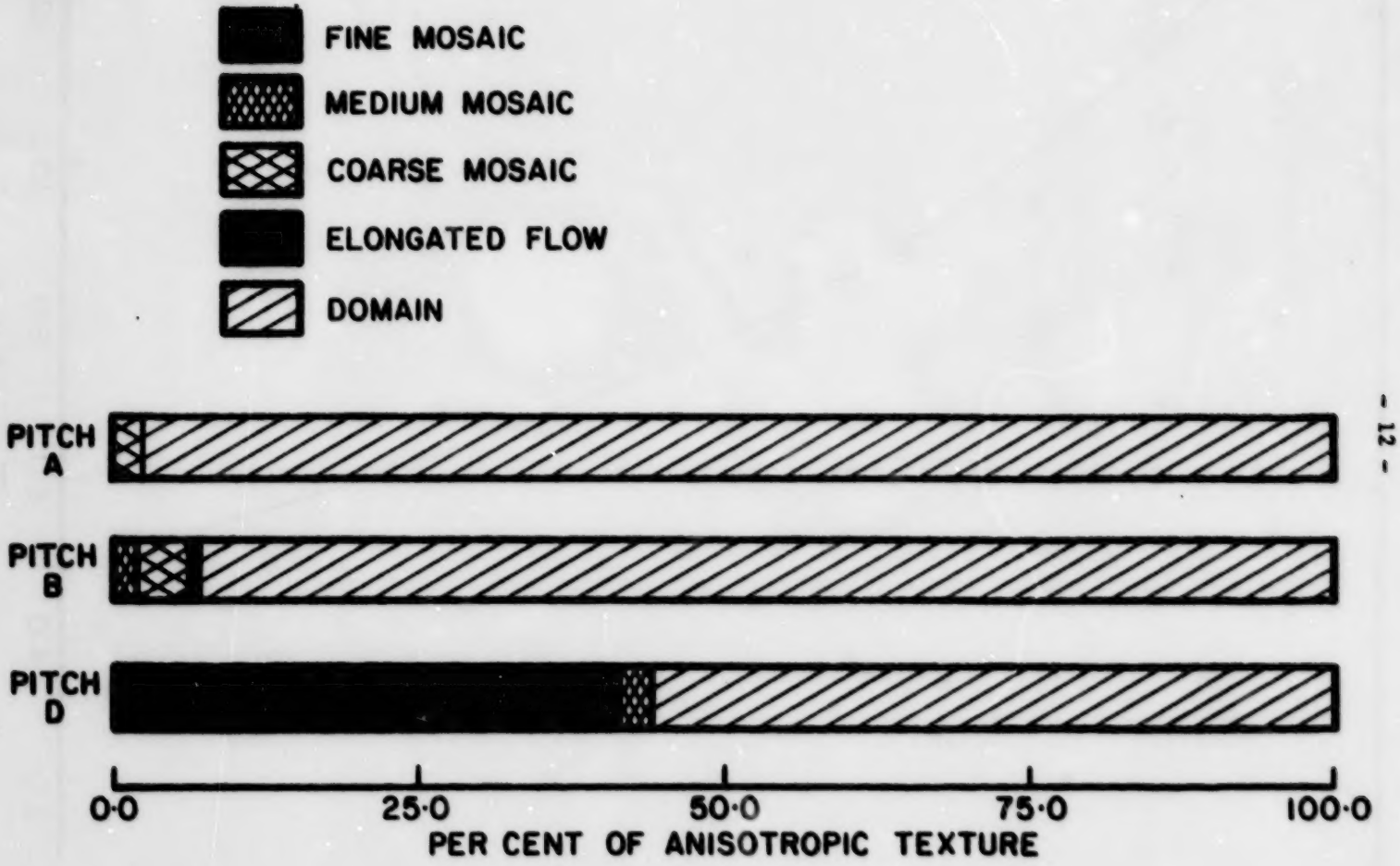

Fig. 5 - Anisotropy of pitches